
SCHOOL OF ADVANCED AIRPOWER STUDIES

# PLANTING THE SEEDS OF SEAD:

# THE WILD WEASEL IN VIETNAM

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# Planting the Seeds of SEAD:

# The Wild Weasel in Vietnam

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School of Advanced Airpower Studies

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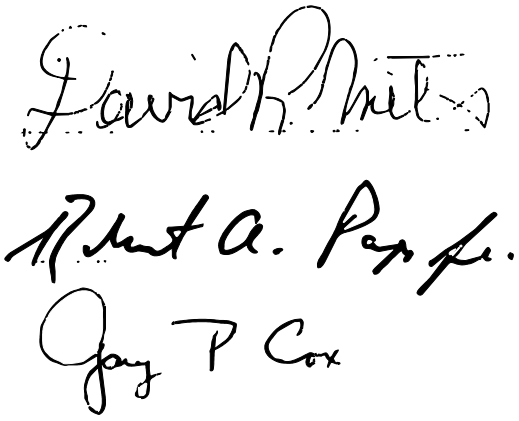


# Disclaimer

ABSTRACT

Aircrews had dealt with threats --fighters and anti- aircraft artillery (AAA) --since the beginnings of the use of aircraft in combat, but the introduction of the Soviet-built SA-2 surface-to-air missile (SAM) in the Vietnam War ushered a new and deadly threat into air war over Vietnam. Although it was not an unexpected threat, having earlier shot down two American U-2 reconnaissance aircraft, the US Air Force's tactical forces were largely unprepared. A counter had to be found, and that counter was the Wild Weasel, a specially configured F-100 F aircraft with electronics for detecting and then homing on radar emissions from SAM sites. The Weasel proved to be an effective weapon for suppressing enemy radar and SAM threats.

Many changes occurred in the Weasel program. The F-100F airframe was too slow to keep up with the primary attack aircraft of the day, the F-105, so the Weasel electronics were added to an F-105 aircraft designated the EF-105 and later redesignated the F-105G. That airframe had too little life left in it and was itself replaced by the F-4C. Following the Vietnam War, the F-4C was replaced by the current Wild Weasel platform, the F-4G, a modified F-4E platform incorporating more capable electronic gear for employment against the mobile Soviet threats.

Along with changes in aircraft came changes in weapons and tactics. The first Weasels employed rockets to mark the target for following attack aircraft who would destroy the SAM sites with bombs or cluster munitions. These tactics required the aircraft to overfly the heavily defended sites, increasing the aircraft's vulnerability to the SAMs and to AAA.

The introduction of Shrike anti-radiation missile (ARM) negated the requirement to overfly the site, but its short range required further improvement. The improvement came in the Standard ARM, a missile that was followed by development of the High-Speed Anti- Radiation Missile, or HARM, the weapon of choice for today's Weasel.

The later years of the Vietnam War also saw the introduction of preemptive launch of anti-radiation missiles. This tactic may well be suited to employment in a raid or anti-shipping campaign where enemy threats need only be shut down for a short period of time. This tactic was well-employed in US actions against Libya in 1986. However, it is not a viable tactic for long-term employment in a defense suppression campaign such as took place in Operation Desert Storm. That mission requires an aircraft capable of selective ARM employment against specific threats.

That aircraft is the Wild Weasel, indicating the need for such an aircraft in the future.

# BIOGRAPHY

I Lieutenant Colonel William A. Hewitt (BA, North Carolina state University; MA, Webster University) is an F-16 pilot. A recent graduate of the inaugural class of the School of Advanced Airpower Studies, he was just assigned to the Commander's Advisory Group, Headquarters Air Combat Command, Langley AFB, Virginia. Also a graduate of Air Command and Staff College, his previous assignment was as an exchange officer with the Royal Netherlands Air Force. Previous assignments were in the F-16 at MacDill AFB, Florida and Shaw AFB, South Car:olina; and in the F-4E as a weapons systems officer at Seymour Johnson AFB, North Carolina, Keflavik, Iceland, and Eglin AFB, Florida.

LEOPARD AND PANTHER FLIGHTS

What had begun as a normal MiGCAP or combat air patrol mission over North Vietnam on July 24, 1965, erupted into violence with the shootdown of one US Air Force F-4C and the damaging of three others.[1] The crews of Leopard and Panther flights had been briefed to cover the ingress and egress of a strike force of F-105Ds attacking ground targets. They expected little resistance from the North Vietnamese at their ingress altitude of 23,000 feet--too high for most anti-aircraft artillery to be effective, and few MiGs had been seen so far in the war. The mission had been uneventful through launch and the early patrol period.

The tense calm was shattered, however, by the radio call: “Bluebells ringing, bluebells ringing,” from an RB-66 electronic support aircraft accompanying the strike force. The cryptic words indicated a FAN SONG guidance radar for the SA-2 surface- to-air missile (SAM) system was transmitting. No SAMs were sighted, but five minutes later the radio again broadcast: “Bluebells ringing, bluebells ringing.” Suddenly the pilot of Leopard 4 saw a long, white missile trailing orange flame and climbing steeply toward the right side of the closely stacked F-4 formation. The missile detonated less than a second later, and the force of the explosion flipped Leopard 2 upside down. Both crewmembers ejected just before the aircraft disintegrated. The rest of Leopard flight took evasive action, and other missiles and detonations were observed by the remaining flight members.[2]

Extensive debriefings of the returning members of Leopard flight left little doubt that Leopard 2 had been downed by a surface-to-air missile. While the real capabilities of this threat were not really known, it was not unexpected. The Soviet SA-2 SAM system was first discovered by NATO intelligence in 1953.[3] “As early as 1956, the potential threat of radar guided missiles had been called by some writers, 'the death of the flying air force.“[4] An SA-2 had

downed Francis Gary Powers' U-2 reconnaissance aircraft in 1960. During the Cuban missile crisis in 1962, another U-2, piloted by Major Rudolph Anderson, had also been shot down by an SA-2.5 Clearly the SAM was a very real threat to US air operations.

Following the first American retaliatory bombing after the Gulf of Tonkin incident in July 1964, the North Vietnamese began a massive build-up of defenses to counter the threat posed by American airpower. Soviet-built fighters were detected operating from North Vietnamese bases in August 1965, and "hundreds of anti-aircraft guns, many of them radar directed, were deployed throughout the country."[6] As early as February 1965, American intelligence officials began to speculate that Soviet SAMs might be deployed to North Vietnam along with Soviet technicians. Photography from U-2 aircraft in April 1965 revealed new installations under construction near Hanoi.[7] The sites had revetted emplacements laid out in what was to become the very familiar six-pointed "star of David" pattern of the SA-2 system, with facilities for radar vans in the center and missile launchers positioned at the points of the star. US photo interpreters correctly identified them as typical examples of SA- 2 sites. By July 4th, the SAMs formed a defensive perimeter around Hanoi.[8] Unfortunately, the sites were ruled off limits as targets for US bombing raids for fear of killing the Soviet technicians helping to build them and train the North Vietnamese to operate them.[9]

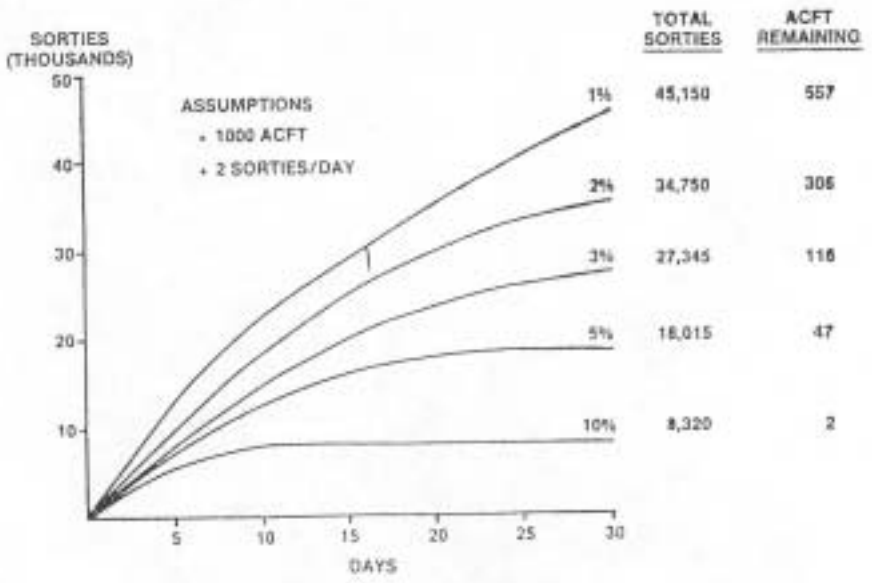
In mid-July, an EB-66 operating from Takhli Royal Thai Air Force Base, Thailand, detected signals from an SA-2's SPOON REST target acquisition radar, and on July 23rd, FAN SONG SA-2 target tracking radar signals were intercepted for the first time. "The evidence of active missile sites was piling up, but no concrete evidence existed that any actual missiles were yet in place. Intelligence experts felt that Ho Chi Minh would not permit their use except in the case of extreme provocation, such as an invasion of the North. ROLLING THUNDER strikes by USAF

fighters continued without change." [10]

BEGINNINGS

Aircrews had dealt with threats --anti-aircraft artillery (AAA) or flak and fighters --since World War I. In fact, antiair defenses appeared soon after man took to the air in wartime. "There are reports of balloon and anti-balloon artillery in the American Civil War and the Franco-Prussian War, and in 1890 the Russians tested a field-gun battery against a balloon moored three kilometers away. The first airplane downed in combat fell to ground fire in the Italo-Turkish War of 1912; so when World War I began, there were precedents for ground-based air defense."[ll] During that war, operations to suppress enemy anti- aircraft artillery (AAA) were confined to strafing and bombing enemy artillery and machine gun positions.[12] Since that time, the mission of "neutralizing, destroying, or temporarily degrading an enemy air defense system in a specific area by physical and/or electronic means,,[13] has come to be known as suppression of enemy air defenses, or SEAD, and has grown tremendously in importance. There are good reasons why. If an air force of 1,000 aircraft flying two sorties per day per aircraft suffered only a 1% attrition rate, that air force would fly 45,150 sorties and have only 557 aircraft remaining at the end of 30 days of combat. If the attrition rate jumped to 10%, that same air force would fly only 8,320 sorties and have but 2 (two!) aircraft remaining at the end of 30 days.[14] The chart (Figure 1) below illustrates more graphically the effects of varying aircraft attrition rates.

Figure 1: Aircraft Attrition Rate Effects[15]




The defense suppression mission has evolved into both non- lethal, the electronic suppression of enemy defenses, and lethal SEAD, the physical destruction of anti-aircraft guns, radars, and surface-to-air missiles. This paper provides a short operational history of US destructive defense suppression efforts, culminating in the development of the WILD WEASEL, an aircraft designed specifically for the SEAD role during the Vietnam conflict. It further attempts to draw some conclusions about the requirement for a WILD WEASEL on the future electronic battlefield.

## WORLD WAR II

The advent of radar in the interwar years made ground-based air defenses, as well as fighters, more effective, and its potential was clearly recognized. The Luftwaffe attempted to destroy the British radar chains at the outset of the Battle of Britain in an attempt to “put Britain's eyes out” and make the rest of the plan for attaining air superiority over Britain easier.[16] Goering spoiled the Luftwaffe's chances when he halted the attacks on the radar chains because of their

apparent ineffectiveness. The Allies also attempted to find and destroy enemy radars. In fact, the British developed a radar homing device dubbed "Abdullah" and fitted it to three RAF Typhoons assigned to 1320 Flight. The equipment, "no CRT [Cathode Ray Tube) or other indicator, just a few small black boxes with switches," worked as intended.[17] However, the aircraft were unarmed, flew only with escort fighters, and provided no new information as the locations of German radars were already well known. Besides, "the radar operators lost no time in shutting down their transmissions on the approach of aircraft,"[18] a tactic that would be seen again in Vietnam and prove equally as effective. The Allies understood the importance of the German radars, however, and flew numerous sorties in attempts to destroy them.[19]

During the Second World War, German anti-aircraft artillery proved to be a formidable -- and deadly --defense against Allied aircraft. An Eighth Air Force report on flak effectiveness (see Table 1 below) states that between the periods January to June 1943 and January to May 1944, total aircraft attrition had been reduced by more than half and damage from enemy fighters had been cut much more sharply. Flak damage, on the other hand, had increased, and in the latter period damaged ten times as many aircraft as did enemy fighters.[20]

| Table 1: Aircraft Lost/Damaged per 100 Sorties | | | |
|---|---|---|---|
| | Lost | Hit by Enemy | Hit by |
| | | | |
| Jan -Jun | 5.5 | 14.2 | 16.8 |
| Jun -Dec | 4.1 | 7.4 | 21.4 |
| Jan -May | 2.6 | 2.2 | 23.3 |

Consistent with the Eighth Air Force report, a 3d Bombardment Division Monthly Anti-aircraft Report for August 1944 reported that of 45,596 aircraft over target, 11,684 had been hit by flak (25.6%), downing 250 (.55%). The report went on to say: "Although fewer sorties were flown during this month's operations a higher percentage of [aircraft] A/C were hit by flak and

shot down by flak. Of the total A/C lost to all causes during the month flak was known to be responsible for more than seventy percent of them. Of the total A/C damaged by all causes flak was responsible for damaging eighty four percent of them."[21]

The Eighth Air Force report recommended a number of tactics to counter the anti-aircraft artillery threat to blind bombing aircraft. Bomber pilots were to avoid overflying flak defenses enroute to and from their targets when possible. Bombers were also to fly at the highest possible altitude consistent with offensive and defensive considerations --clouds, formation, target visibility and size, and bomb pattern or spacing requirements, for example. The report also recommended planning bomber spacing and axes of attack to make the fullest use of the WINDOW and CARPET countermeasures.[22]

WINDOW was the codename for chaff, thin strips of aluminum that "plumed" when deployed, reflecting a much larger image to the radar on the ground and adding to the radar operators' confusion. Laid in trails, the chaff formed a protective screen for bombers flying within two thousand feet of the stream, and Eighth Air Force advised that bombers should not attack from a heading more than five degrees different from the WINDOW dispensing aircraft to avoid flying outside the chaff's protective trail. CARPET was a radar jammer which caused interference in the anti-aircraft artillery (AAA) radars' reception of signals. Analysis showed that aircraft had very little protection from radar detection when flying more than two miles from the CARPET-equipped aircraft. Optimum spacing was approximately one mile.[23]

These requirements contrasted with another recommendation of the report, to increase the spread of the entire bomber formation in altitude and breadth. Anti-aircraft artillery was usually fired at the center of a formation of aircraft rather than at a particular aircraft. The reduced density of the spread formation reduced the number of targets available in a gun's firing pattern

and reduced the number of aircraft vulnerable to shrapnel from any burst of flak. Bomber pilots were also urged to close up their formations in trail to put as many aircraft across the target as possible in the least amount of time, reducing time on target and saturating enemy flak defenses.

Besides these non-lethal suppression tactics, more direct methods were also used to counter the deadly flak. The first major operation of Eighth Air Force during Operation Market Garden, the September 1944 Allied assault to place three divisions behind German lines and seize the bridges over the Maas, Waal, and Lek Rivers at Arnhem, the Netherlands, and in the surrounding countryside, was "bombardment of the anti-aircraft installations along the routes to be followed by the troop carrier aircraft and in the areas surrounding the drop and landing zones."[24] Planners selected a total of 112 targets based on intensive photographic intelligence coverage and other information, requiring a force of 874 aircraft to adequately cover the planned targets. B-17s of the First and Third Bombardment Divisions were chosen for the missions and most were armed with fragmentation bombs because of the low probability of direct hits on such pinpoint targets. The exceptions were those aircraft targeted against buildings housing enemy troops where half of the 24 assigned aircraft were armed with 100-pound high explosive bombs. The bombardment divisions launched 872 aircraft on the raids and 852 attacked their targets, bombing at altitudes from 10,300 to nearly 23,000 feet. "The two bombers which failed to return were credited to anti-aircraft and battle damage to 112 aircraft (91 Category 'A', 20 Category 'AC', 1 Category 'B') was attributable to the same cause." [25]

Bombers were not the only aircraft taking part in flak suppression operations. Four P-47 fighter groups from Eighth Air Force bombed and strafed ground defenses along the southern ingress route while four P-47 groups from Ninth Air Force provided "anti-aircraft neutralization support." [26] Owing to the lethality of the German anti-aircraft artillery, the P-47s were assigned

to flak neutralization "in view of their sturdy construction enabling them to withstand considerable damage without serious impairment of their flying ability." Their heavy firepower also made them very effective. The P-47s dropped two hundred eighty seven 260-pound bombs and expended 122,619 rounds of .50 caliber ammunition in bombing and strafing the flak installations. Pilots claimed 59 anti-aircraft positions put out of action and 80 damaged.

The flak proved lethal to the fighters as well as the bombers. Of the 36 P-38s and 306 P-51s which took part in the covering operations for the Market Garden support missions, three of the seven P-51s lost were shot down by anti-aircraft artillery fire, with only one lost to an enemy aircraft.[27] An earlier report by the Headquarters, U.S. VIII Fighter Command on battle damage and losses of u.s. fighter aircraft pronounced flak as the "most important cause of damage and 1oss ." [28] Of the tota1 fighter aircraft damaged considered by the study, 841 or 63.2% had been damaged by anti-aircraft artillery, and of the aircraft lost, 178 (27.0%) had been downed by flak.[29] Mission also affected loss rates: "As the Fighter Command operations have changed, the various causes of damage and loss have shifted in importance. The most striking trend has been the increase in the importance of flak as the ground-strafing operations have increased in volume."[30] This claim is clearly borne out by the numbers, as indicated in the table below, which were worse for aircraft which flew closer to the ground --and the threat. A far greater percentage of aircraft were lost in ground strafing and in the fighter-bomber role than were lost escorting bombers.

| DAMAGE AND LOSSES OF US FIGHTER AIRCRAFT [31] | | | |
|---|---|---|---|
| | Sorties | Aircraft damaged per 1000 sorties | Aircraft lost per 1000 sorties |
| Support of bomber | 31,688 | 23 | 10 |
| Sweeps | 1,999 | 35 | 13 |
| Ground strafing | 1,723 | 80 | 36 |
| Fighter-bombing | 1.722 | 49 | 9 |

This trend is confirmed by a 56th Fighter Group mission summary report from the time frame of Operation Market Garden, September 18, 1944. Thirty nine P-47s took off in the afternoon for a mission against targets in the Turnhout area. The group arrived in the target area at low altitude because of low clouds and haze which made it impossible to find targets at higher altitudes and were forced to split up by "intense flak." Of the 39 aircraft in the flight, 16 were lost --nearly 40% --and all believed lost to flak.[32] Whatever the aircraft, anti-aircraft artillery was clearly the most lethal threat, and the closer the aircraft operated to it, the more lethal it became.

In the Pacific, operations virtually mirrored those in the European theater. As the Japanese increased the numbers and sophistication of their radars, the US increased the numbers of assets assigned to counter them. The US forces employed B-24 and B-29 II ferret" aircraft to locate and jam the Japanese radars. B-25 gunships equipped with radar homing receivers were used in the lethal suppression role, flying down a radar beam until they located the site visually and attacking it with their nose mounted cannons.

In the Second World War, ground-based air defenses proved to be a lethal counter to US

airpower. However, loss rates varied with the mission flown. Aircraft which operated at lower altitudes were much more vulnerable to enemy flak than those which operated at higher altitudes. Destructive defense suppression efforts were only part of the solution to the flak problem. Good tactics and the use of electronic countermeasures were also important means for reducing aircraft loss rates. These conclusions would also be borne out in later wars.33

## THE KOREAN WAR

During the Korean Conflict, the Communist AAA was not comparable in either quality or effectiveness to that encountered by the USAAF in World War II; however, numerous Far East Air Forces intelligence reports record that enemy opposition consisted mainly of automatic weapons and heavy anti-aircraft fire. Losses reflected nearly the same percentages as had been recorded in World War II. “In 721,000 air sorties by all types of aircraft, the USAF lost 1465 aircraft --but of these, only 139 were lost in air-to-air combat for the entire war. Some 500 were lost for operational reasons not due to enemy action (i.e. engine failures, etc.) and the remainder were primarily victims of ground fire.”[34]

Again, anti-aircraft artillery had proved its effectiveness. As evidence of its impact on air operations, consider the different results obtained on two bombing raids against North Korean targets. “Poor results were obtained in the August 29 [1951] strike on the M/Y [marshalling yard] at Maenjungdong (vicinity of Sinanju). Flying through intense flak, eight B-29s attempted to knock out this key transfer point. Some of the bombs did hit the target, but for the most part they were 'near misses. '”[35] On another mission, “the attacking aircraft --35 medium bombers -- found the target CAVU [refers to the weather: clear and visibility unrestricted], and were able to knock out their target with ease. It is highly probable that this attack caught the enemy completely unaware, since no opposition, either from fighters or flak was encountered. A

detailed description of the damage and destruction inflicted would be to lengthy but portions of the bomb damage assessment reports read as follows: 'yards resemble Swiss cheese', 'entire target area saturated with bombs', 'turntable obliterated', and 'widespread devastation' ."[36]

American defense suppression efforts also resembled those of the Second World War. For example, Far East Air Forces reported in July 1951 that "armed reconnaissance flights consisted of flak suppression missions and airfield strikes, cutting rail and communication lines, attacking troop concentrations and supply areas and bombing and strafing rail and vehicular traffic."[37] Again on July 25, 1951, F-80s attacked flak positions in the Sinanju area.[38]

Suppression missions were not confined only to fighters. B-26s conducted raids to suppress anti-aircraft artillery in support of B-29 bombing raids against the North by bombing searchlights. The radar- or sound-aimed searchlights were used by Communist gunners to illuminate the bombers overhead. The lights proved to be a difficult target, but "the overall result of US electronic countermeasures, chaff, and B-26 searchlight suppression was a material factor in reducing... losses from fighters and flak...."[39] UN forces also used army field artillery to destroy enemy AAA batteries in support of close air support sorties. Again, it was the combined effects of lethal defense suppression and non-lethal electronic countermeasures which proved effective in reducing losses of friendly aircraft to ground-based defenses.

## THE VIETNAM WAR

In Vietnam, the SAM added a new and lethal dimension to aerial warfare and ground-based air defenses. Then, on July 24th, 1965, the crews of Leopard and Panther flights briefed their mission. They were advised of the intercept of FAN SONG signals in the mission area the day before and planned their MiGCAP orbits to remain outside the lethal radius of the known SAM sites. The SAM posed a serious threat to US air operations, and the shootdown of Leopard 2

brought that point home.

## WILD WEASEL I

Clearly, a counter to the SA-2 threat had to be found. The US Navy had already equipped some of their attack aircraft with radar homing and warning receivers. A-4s, and later A-6S, were used to lead Navy and Air Force strike aircraft in attacks against SAM sites. A version of the A-6, the A-6B, was developed by the Navy and Grumman specifically for the SAM suppression role. But the Air Force had nothing of the sort, and had, in fact, turned down a Bendix Corporation proposal for installation of radar homing equipment in an F-100F in the spring of 1965 because there was no requirement for it.[40] Then, on August 13, 1965, the USAF Chief of Staff, General John P. McConnell, directed formulation of a special task force (Air Task Force) under Brigadier General K.C. Dempster to study this threat and to recommend ways to counter it. The Air Task Force made a number of recommendations:

> -To modify a small number of fighters with electronic equipment to enable them to find active SAM sites. These aircraft would mark the active sites for destruction by accompanying IRON HAND strike aircraft.
>
> -To develop a missile that could be fired from a fighter and home on a radar emitter.
>
> -To develop jamming equipment for carriage on fighters to counter the SAM radars.
>
> -That a Radar Homing and Warning (RHAW) capability was needed immediately--a capability that would provide warning to the aircrews that a SAM radar was looking at them and provide some clue to its location.

To meet those needs, the Air Force acquired the Vector Homing and Warning System, the IR-133 Panoramic Scan Receiver, and the WR-300 Receiver, all off-the-shelf equipment produced by Applied Technology, Incorporated for installation in a fighter aircraft dubbed Wild

Weasel I. The Vector provided 360 degree warning of S, C, and X-band radar signals, the frequency bands for early warning, gun-directing, and surface-to-air missile radars. Threats were displayed on a small, circular CRT, and a strobe indicated the direction of the threat from the aircraft. Additionally, the Vector included a threat panel which indicated whether the signal was from a SAM, AAA, or early warning radar. [41]

The IR-133 received radar pulses through a set of antennae located symmetrically around the nose of the aircraft. The signals could be analyzed for frequency --which also told the crew whether the signal was from a SAM, anti-aircraft gun emplacement, or some other type of radar --and repetition rate --which indicated whether the radar was in a search, tracking, launch, or guidance mode. By comparing the signal strengths on each side of the aircraft's nose, the EWO could tell the pilot to turn right or left to home on the signal. Test personnel thought at first that this technique could also be used to determine range to the emitter through a quick triangulation, but small differences in offset made tremendous differences in range. For instance, if the electronics indicated the emitter was 10 left with the aircraft rolled into 900 of left bank at 1,000 feet above ground level over flat terrain, that would indicate the site was 10 NM away (10 at 10 nm = 1000 feet of altitude difference). As indicated above, the problem came in determining small azimuth differences and translating that to range, since as range doubles, azimuth halves. Thus, at 1/20 of elevation (itself difficult to determine on any CRT), the emitter site would be 20 miles away, while at 1/40, the site would be 40 miles away. Such small differences in elevation made tremendous differences in range calculations. The technique was abandoned, and the range problem plagued the WILD WEASEL I crews throughout the test and in actual employment.[42]

The WR-300 provided indications of launch of the SA-2 by monitoring the SAM's guidance and control frequency. When the gear detected a characteristic shift in the power of the signal, it

illuminated a bright red LAUNCH light in the cockpit of the WEASEL.[43]

The equipment was installed in four F-100F aircraft (the two seat version of the F-100) and designated Modification 1778. The F-100F was chosen because it was immediately available, and the extra cockpit would provide a place for the electronic warfare officer (EWO) who would operate the electronic equipment. In modifying the aircraft for the new Wild Weasel role, the aft cockpit instrumentation and controls were removed and replaced by the electronics package. The crew concept would allow the EWO to concentrate on identifying and locating threat radars while the pilot concentrated on flying the aircraft, searched visually for the SAM sites, marked them for the following strike aircraft, and took evasive action against threats. The initial testing, Tactical Air Command Test 65-83 and Air Proving Ground Center-TR- 65-83, was conducted at Eglin Air Force Base, Florida and successfully completed on November 19, 1965.[44]

According to the WILD WEASEL I Final Report, "the operational necessity for an immediate RHAW [Radar Homing and Warning] capability to counter the missile threat, led to the decision to complete the operational test and evaluation of the Modification 1778 equipment in the combat environment."[45] On November 20th, 1965, just four months after the initial loss of Leopard 2 to an SA-2, the four modified F-100F aircraft and the WILD WEASEL test team departed Eglin AFB for Southeast Asia. The Southeast Asia phase was to be a continuation of the Eglin test.

It was hoped that "combat operations in the theater plus face-to- face contact with the actual threat [would provide] the ultimate test of equipment and tactics. "[46]

## THE SOUTHEAST ASIA TEST PHASE

The Southeast Asia phase of Wild Weasel I testing lasted sixty days, from November 28, 1965 to January 26, 1966. The goal of the test was to evaluate the Wild Weasel equipment and

tactics against the following eight objectives:

> (1) “To determine the warning capability of RHAW equipment installed in the Wild Weasel F-100F aircraft. .,
>
> (2) “To investigate the effect of jamming, by friendly aircraft, on Vector and IR-133 equipment.”
>
> (3) “To determine the homing accuracy of the RHAW equipment and the capability of the crew to place the aircraft within visual range of the target.”
>
> (4) “To develop tactics for employing the Wild Weasel aircraft against SAM defense systems.”
>
> (5) “To determine maintenance requirements and reliability of RHAW equipment.”
>
> (6) “To determine the organization and manning requirements for Wild Weasel operations.”
>
> (7) “To determine training requirements for flight crews and RHAW maintenance personnel.”
>
> (8) “To test any additional equipment which may be made available for this system during the period of the operational test and evaluation.” [47]

During the test period, the four Wild Weasel crews and aircraft flew 112 of 135 scheduled sorties, including 44 Iron Hand Strike (the name given to attacks against SAM sites) and 32 ELINT (electronic intelligence) missions, totaling nearly 250 hours.48 The first sorties flown in the F-100F in theater were orientation missions, flown along with RB-66C and B-66B aircraft on regularly scheduled electronic counter-measures (ECM) and ELINT missions. The purpose of these missions was to provide the crews with an area orientation, experience in the multiple threat environment, to “establish preliminary verification of the RHAW capabilities determined during the Eglin phase of Wild Weasel I testing, and observe the effects of jamming on the Vector and IR-133.”[49]

IRON HAND strike sorties were of two types, each specifically assigned (fragged) by the Second Air Division (2 AD) and planned to support either Joint Chiefs of Staff (JCS) directed

strikes or search and destroy missions.50 During JCS support missions, the Weasels would accompany the main strike force against JCS-selected targets. The Weasels' primary objective was to destroy or neutralize SA-2 installations that posed a threat to the strike force. While primary emphasis was on the target area defenses, the Weasels could also attack threats either going in or coming out. On search and destroy missions, the Weasels were fragged to search a particular geographical area and home on and destroy any SAM sites found. These missions usually coincided with other strikes in the general area in hopes of bringing up the SAM radars. Strike sorties were flown with Weasels and F-105 aircraft. In addition to carrying out strikes against enemy ground targets and defenses, the objective of the missions was to define and develop tactics for RHAW employment against the SA-2. The crews looked at the Wild Weasel concept of operations, formation sizing and spacing, mission profiles, munitions and load combinations, mutual support, and diversionary operations.[51]

In addition to the orientation and strike sorties, the Weasels also flew ELINT sorties with the EB-66s to collect electronic intelligence and, most important, to verify the ELINT capability of the F-100F equipped with the Vector and IR-133 systems.[52]

## TEST RESULTS

Overall, the test results were very positive although there were also a number of limitations found. On orientation and ELINT missions, 109 intercepts of radar signals were recorded by the Weasel and RB-66C crews, time correlated, and compared for signal identification. Of these, 84 signals were received and identified simultaneously by the F-100F and RB-66 crews. The crews identified the same signal type in 71 of those 84 cases. Where bearing (azimuth) correlations were possible, they were in general agreement. Azimuth differences ranged from 0 to 32 degrees, with most in the 5 to 15 degree range.

The tests also revealed that the Vector was not affected by the jammers on the RB-66C and B-66B aircraft. However, the IR- 133 was subject to interference by the jammers, which showed up as "grass" or noise strobes on the IR-133 scope display. Interference was severe enough to hinder performance of the equipment (and the effectiveness of the Weasel) inside 1 NM range but decreased as range increased. Between 1 and 3 miles, jamming did not degrade mission accomplishment as it did at shorter ranges, and outside of 3 NM, jamming was rarely seen.

The results of the test in another mission area, homing accuracy, were more difficult to determine. The Eglin tests indicated a homing accuracy for overflight to be an average of 77 feet for 235 test runs. It was more difficult to determine in the combat environment. One unexpected problem was in visual acquisition of a camouflaged SAM site. The North Vietnamese often placed the sites among trees or small villages, making visual acquisition extremely difficult. Three IRON HAND missions apparently resulted in overflight of an SA-2 site during the test phase. On two of these missions, the crew could not visually identify the site even after the onboard electronics indicated the aircraft had overflown the sites. On the third, the F-100F pilot and F-105 pilots saw the missiles in the SA-2 complex under thatched roofs and fired 304 2.75 inch rockets into the target area.

Another mission, flown on December 20, 1965, resulted in the loss of an F-100F to anti-aircraft artillery fire, but also apparently resulted in a site overflight. The Weasel pilot climbed abruptly approximately five miles southeast of the Kep airfield, turned hard to the right, rolled the aircraft back left to level the wings, and then fired his marking rockets. The Weasel then pulled off to the right and transmitted, "I am hit," having taken a 37MM shell in the afterburner of the aircraft while working the radar signal. Although an F-105 pilot saw only some small buildings and trees in the area marked by the Weasel, he fired his rockets into the target area

anyway. His wingman followed suit. A second element of F-105s which had been separated from the flight, spotted the wounded F-100F and followed it. They observed pieces falling off the aircraft as it tracked toward the east-northeast. Then the canopy came off the aircraft, one parachute opened, and the F-100 pitched over into the clouds and disappeared.[53] The pilot, Captain John Pitchford, was to become the first Weasel POW and was returned to the US after more than 7 years in prison, coming home in 1973. His EWO, Captain Robert Trier, was killed fighting the Vietnamese attempting to capture him. His remains were not returned until November 3, 1982.[54]

Despite the loss, the Weasel had proved its effectiveness. The operational test and evaluation of Wild Weasel I had proved that radar homing to counter the SAM threat was possible. However, at this point, visual transition from the electronic target mark to visual acquisition of the SAM site was required to complete the search and destroy mission, that is, to attack the target. The crews concluded that the Weasel must have a better target marking capability to aid the strike aircraft in visual target acquisition. Further, the crews needed range-to-threat information, and a precise navigation system would greatly improve the capability of the Weasel aircraft.[55]

On a more operational note, the testing also indicated that the search and destroy missions could achieve some degree of tactical surprise through the use of terrain masking (flying the aircraft in valleys or behind high terrain, below the radar horizon or line of sight of the threat) and the employment of small force sizes. Four or five ship formations were found best for the search and destroy mission. The crews also believed the orientation flights flown with the EB-66s were essential training prior to participating in live search and destroy missions.[56]

The test report also noted a number of limitations inherent in the Wild Weasel I equipment.

The Wild Weasel I equipment could not determine whether the aircraft was being tracked by the FAN SONG radar; it could only detect the change in the radar signal, not whether a particular aircraft, even itself, was being tracked. Additionally, the IR-133 was not usable as a homing device under the frequent evasive maneuvers required to dodge anti-aircraft fire or when the receiver was saturated by strong signals.[57]

The crews also found that the Vector equipment had a high false alarm rate.[58] This problem was compounded by the number of emitters in the radar environment, even in the semi-sophisticated North Vietnamese air defense network. During the initial test, 57% or 73 radars operated in the S-band, including early warning, anti-aircraft artillery, ground controlled intercept, and surface-to-air missile radars. Typically, one to eight signals were present simultaneously, and it was these multiple signals that generated the frequent false alarms through the Vector logic circuitry. The problem of hostile radars was compounded by the presence of friendly radars. "US airborne and shipborne radars, as well as RB-66 jamming, occasionally interfered with Wild Weasel operations but did not preclude mission accomplishment. 1,59 The problem of the dense radar environment was compounded at higher altitudes where increased line of sight allowed contact with more emitters. This problem was reduced at lower altitudes, 4,500 to 8,000 feet, where search and destroy missions were usually flown.[60] The EWO was required to ".... call upon his background, knowledge, training, and in-theater experience, to correlate the signals with the IR-133 in order to interpret correctly the complex array of information."[61]

## THE THREAT

While the SA-2 presented the most apparent threat to the Weasel mission, automatic weapons and anti-aircraft artillery fire presented the greatest hazard to Wild Weasel operations,

just as they had for other aircraft in previous wars. Below 2,000 feet, small arms were the most serious threat, but a Second Air Division directive limiting most operations to altitudes above 4,500 feet, the maximum effective altitude of small arms fire, limited the effect of these weapons.

However, the North Vietnamese possessed an impressive array of other anti-aircraft weaponry. The Pacific Air Force's (PACAF) Enemy order of battle for Southeast Asia included 14.5, 37, 57 85, and l00mm gun batteries, with effective altitude coverage up to 45,000 feet. The effectiveness of these weapons varied with gun concentration, weather, and the type of attack flown by the aircraft aimed fire, Evasive action by US aircraft limited the effect of thus most fire encountered by US aircraft was barrage type, where the defenders simply put up a wall of flak in front of the attacking aircraft. The AAA was most effective if the cloud bases were below 8.000 feet as this allowed the gunners to set the fuzing of the shells more accurately at the same time that aircraft vertical maneuvering was restricted by the clouds.

The SA-2 was also numerous as well as deadly. The number of sites would increase dramatically, from 9 in late summer to over 25 by early December.[62] Between 22 and 24 SA-2 systems were operational during the Wild Weasel I test period. After launch the missile accelerated to Mach 3.5 and had a maximum range of about 25 miles.[63] It could intercept targets flying as high as 50,000 feet, but was “generally ineffective against aircraft flying at high speeds at altitudes under 3000 ft.”[64]

The Weasels did not encounter the enemy air threat and there were no direct enemy air engagements although "several suspected SPIN SCAN and SCAN ODD [the air-to-air radars of North Vietnamese MiGs] radar intercepts were noted. 1165 As of January 3, 1966, aircraft, the North Vietnamese possessed 63 MiG 15/17 FAGOT/FRESCO 11 MiG 19/21

FARMER/FISHBED aircraft, 16 of which were radar equipped, 25 plus 15 MiG 15s and 50 MiG 19s in south China. [66]

The threats had a synergistic effect. The small arms and automatic weapons fire drove the aircraft out of the low altitude arena to higher altitudes where other AAA, SAMs, and enemy fighters were more effective. At the same time, the heavier AAA, SAMs, and fighters drove the aircraft back down to lower altitudes where those threats were less effective but the small arms fire was murderous.

## TACTICS

To counter the threat, the Weasel crews developed tactics that varied according to the situation that confronted them. The electronic gear provided some measure of protection through its reception of the S-band signals of the SA-2's acquisition radar, C-band signals of the AAA radars, and X-band transmissions of airborne intercept radars. This capability permitted them to circumnavigate radar-controlled defenses.[67]

Early in the tactics development phase, the crews decided that on strike missions the F-105 flight lead would act as leader for the mission until the flight reached a certain geographical point or until the F-100F received signals from a FAN SONG radar. At that point, the Weasel would assume the tactical lead of the flight, and the search phase of the mission would begin. The F-100F would fly at approximately 400 knots with the F-105s staggered in elements behind in an offset trail. Because of the relatively slow speed of the F-100F compared with that the F-105 pilots wanted to fly, the Thuds [68] were forced to weave behind the slower aircraft to keep from overtaking him. The search would take place between 4,500 and 14,000 feet, high enough to be out of range of small arms fire and to receive the FAN SONG radiations, but low enough not to clutter the electronics with extraneous signals. If the Weasel received a workable FAN SONG

signal, the F-100F would turn towards the emitter and begin a gradual descent. If the Weasel could determine an accurate bearing to the site and a homing run was imminent, the Weasel transmitted “Contact” to the flight to key the F-105 pi lots that the fight was on. At this point, the Weasel could employ terrain masking to reduce the probability of the flight being acquired by the SAM site, but this also took away the Weasel's bearing to the target. The flight remained at low altitude until it was necessary for the EWO to get another “cut” or bearing on the SAM site. If the electronics indicated the flight was being engaged by a SAM, the Weasel transmitted “take it down,” and the flight began evasive maneuvers to break the SAM's radar contact or to descend below the SA-2's minimum effective altitude. Again, this placed the flight in the heart of the AAA envelope, and it also took away the Weasel's bearing information. While the EWO called out headings for the pilot to fly, the pilot searched visually for the SAM site (remember they had no range information!). If the pilot saw the site before it was overflown, he initiated the attack by calling “tally ho” to the Thuds and marking the target. More likely, the Weasel ended up overflying the site due to the effective camouflage of the North Vietnamese. As the aircraft passed overhead, the electronics would indicate station passage, and the Weasel would begin a steep, climbing turn in an attempt to visually acquire the site and begin the attack.[69]

Once the target had been seen, the Weasel would dive at the target, fire his marking rockets (the 2.75” rockets with HEAT or HEAP warheads also were highly explosive and capable of killing the target)[70] and allow the F-105s to finish the job. Typical ordnance loads for the Weasel included two LAU-3 cannisters, each with 24 rockets, and a full load for its gun.[71] The Thuds generally carried four LAU-3 rocket cannisters or six 750 pound bombs and two rocket pods.[72]

## CHANGES: WILD WEASEL III

Changes were also in the works for the Weasel program. An 8 January 1966 decision by

General Dempster to upgrade the Weasels to a higher performance aircraft resulted in the delivery of the first Wild Weasel III, a two seat F-105F, on May 28, 1966. The Wild Weasel III had essentially the same electronic equipment as the Wild Weasel I: the Vector (now designated the APR-25), the IR-133, the WR-300 Launch Warning Receiver (now called the APR-26), and a new addition, the AZ-EL system which provided both bearing and elevation information to the threat radar. The Wild Weasel III, also called the EF-105F for electronic fighter, retained their internal M61 gatling gun, full ordnance capabilities, plus the capability to launch the new addition to the Weasel line-up, the AGM-45 Shrike.[73]

The Shrike, a radar-homing or anti-radiation missile (ARM), was the result of a Navy development program begun in 1958. The first Shrikes were delivered in March of 1966 and first saw action in April of that year.[74] While the Shrike added more muscle to the Weasels' armament, increased the stand-off weapons delivery capability, and solved some of the problems associated with having to overfly the SAM sites to identify and kill them, there were also some limitations in Shrike employment. Its maximum aerodynamic range was around seventeen miles, but employment range was much shorter, around 12 miles.[75] At longer ranges, the SAM crew could launch a missile, guide it to intercept of an aircraft, and have the radar shut down before the AGM-45 could hit the site. This was a product of the Shrikes relatively slow (Mach 2.0) speed compared to the Mach 3.5 SA-2.[76] Additionally, the SAM crews demonstrated the capability to track the ARM once it had been fired from the attacking aircraft.[77] They would then shut down the radar, depriving the ARM of its homing signal. Without the radar signal, the Shrike had no means of finding its way to the target. Thus, pilots wanted to be at a range at launch of the Shrike where its time of flight would be shorter than the time of flight of the SAM. That meant a maximum effective range of ten to twelve miles.[78] Additionally, the small warhead

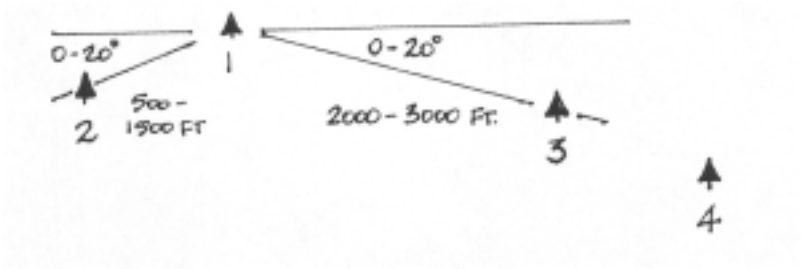
(145 lb high explosive)[79] on the SHRIKE did comparatively little damage. Pilots such as Lt Col Robert Belli found, "in fact, when we fired at the FIRE CAN radars or SAM site, … we found that usually twenty-four hours later the same site was up in the general area. We figured all they did was change the antenna."[80]

Besides its short range, the AGM-45 also required the aircraft to loft the missile, or pull up to launch it. This caused the aircraft to slow down as it climbed, generally making it less maneuverable and more vulnerable to any threats in the area.[81]

Along with changes in aircraft and weapons came an evolution in employment. The Weasel mission had clearly divided into two categories. IRON HAND missions were designed to suppress the SA- 2 and "gun-laying" defenses during the ingress, attack, and egress of a strike force. Using the AGM-45 Shrike to kill, or at least harass, the SA-2 and AAA radars, the threat of the IRON HAND flight diverted attention from the strike flight, also a form of suppression. According to the 388th Tactical Fighter Wing F-105 Tactics Manual, "the actual destruction of SA-2 sites [was] normally of secondary importance in the suppression role and [would] not normally be carried out unless a particular site [could] be destroyed without sacrificing the protective suppression the strike force [required] from other threatening sites. However, for particular targets, SA-2 site destruction may [have been] the best and most permanent form of suppression."[82]

In the suppression role, the IRON HAND flight arrived in the target area of the strike approximately 20 to 30 minutes ahead of the strike package. That allowed them to "stimulate" the radar threats, trying to bring them on line so they could be neutralized before the strike flight arrived. Other suppression aircraft might also accompany the strike flight.[83] The IRON HAND flight maneuvered between the strike flight or force and the threat. The flight typically flew at an

altitude between six and nine thousand feet, at an airspeed of 500 knots or greater, a significant difference from the F-100F days where the Weasel flew at around 400 knots! The flight of four Thuds was usually split into elements of two aircraft, allowing one element to monitor the electronic environment while the other worked to suppress or neutralize a threat radar.[84] Weather and the threat of MiGs determined the formation, but a typical good visibility formation would have the wingmen flying from line abreast to twenty degrees aft of the leader, split from 500 to 1500 feet out. The second element would assume the same formation, with number 3 separated 2,000 to 3,000 feet from number 1 and again from line abreast to twenty degrees aft.[85]




The SHRIKE could be employed anywhere between 3 and 13 miles range at the flights' typical ingress altitudes, but no range information was available to the crew. Thus, launches had to be either preplanned or correct interpretation of the aircraft cockpit Shrike delivery needles was paramount.86 Typical bomb loads for IRON HAND flights had numbers 1 and 3 carrying two CBU- 24 cluster bomb munitions while the wingmen generally carried two M117 750-pound bombs. If the flight included an F-105D, that aircraft usually carried six MK-82 500-pound general' purpose bombs on a centerline multiple ejector rack (MER) for follow-up attacks on a SAM site, for targets of opportunity along lines of communication, or at specified “dump” targets.

In the Wild Weasel role, suppression of enemy defenses for the strike force was not a factor and the mission was flown with a hunter-killer team of F-105s. The Weasel flight directed its

entire efforts toward finding and killing or destroying SA-2 and FIRECAN AAA radar sites. Otherwise, the missions were similar. The Weasels were constantly being upgraded [87] to make them more effective. Along with improved electronic equipment came

one of the most important changes--the addition of a capability to fire the AGM-78 Standard ARM. The AGM-78 was a 1966 development of the Navy's Tartar surface-to-air missile.[88] Its improved electronics and seeker head, greater payload, longer stand-off range (up to 35 miles),[89] and somewhat faster Mach 2.5[90] speed, though still slower than the SA-2, made it the weapon of choice for Weasel crews. The missile allowed the crews to launch without pointing directly at the SAM site, a factor that reduces the maximum effective range of the SAM. The seeker head of later versions of the AGM-78 could also be tuned to isolate a particular radar frequency, and, unlike the AGM-45, the Standard ARM had a memory circuit which allowed it to proceed to the target even when the radar had been shut down. [91]

From the very beginning the Air Force also saw a need to update the Weasel platform, reflected in the almost immediate change from the F-100 to the F-105 at the beginning of the program. Another change was also in the wings, as the Air Force sought to replace the F-105. Where the F-100F was just not fast enough to keep up with other aircraft in a suppression package, the F-105 didn't have enough life left in the airframe.

Production of the aircraft had ended, and any losses could not be replaced, requiring development of another Weasel platform. That new aircraft was the F-4C, Wild Weasel IV, but installation and integration of the Weasel equipment in that aircraft proved more difficult than initially expected despite the feverish efforts of McDonnell-Douglas engineers. In fact, installation of the electronics in the first F-4C Weasel began in June 1968, some two years after the scheduled deployment of the first F-4C Wild Weasels! The first aircraft was finally

completed in the summer of 1969.[92] In one sense, the F-4C represented a step backward for the Weasel program, as the F-4 Weasel was not Standard ARM capable and relied on the short-legged AGM-45 Shrike for its anti-radiation missile capability.[93]

This weapon system would in time be further modified with plans begun about the time the first F-4C Weasel rolled out of McDonnell-Douglas. In a letter to Tactical Air Command, USAF Chief of Staff General John D. Ryan revealed initial US Air Force plans to modify 90 F-4Ds, and two aircraft were modified to WILD WEASEL configuration.94 The plan called for development of an advanced avionics system that would "satisfy future Wild Weasel requirements while still retaining the capability to perform the basic tactical fighter role," with the potential for installation in other tactical fighters when the F-4D program was completed.[95]

But the F-4D Weasels had the same major problem as the F-4C Weasels: they were not Standard ARM capable. Additionally, the APS-107 radar homing and warning receiver installed in the F-4D, although more sophisticated and accurate than the APR-25/26 equipment installed in earlier Weasels, was not reliable enough under combat conditions for Weasel use. The F-105 and F-4C would continue as the USAF Wild Weasel force through the Vietnam War. General Ryan's letter also stated that efforts were underway to redesignate the F-105F Wild Weasel aircraft as the F-105G, a move made "to ensure that Wild Weasel assets can be identified in appropriate programming documents and resources allocated accordingly...."[96] That designation would carryon to the next Wild Weasel aircraft, the F-4G.

Beginning in April 1972 with the resumption of full combat operations, another change to Weasel tactics also took place. Preemptive launch was used extensively for suppression. "In this tactic, an AGM-45 Shrike is fired at a known SAM site, but without any signal from the site. This, of course, is purely a suppression technique, and is not expected to damage enemy radars.

As of 31 October [1972], there were no reported instances of a radar corning up during the flight of a preemptive [Shrike], and then being damaged by the missile.

"Judging the effectiveness of this tactic is difficult at best. It is difficult to establish that a preemptive SHRIKE launch was what kept a particular SAM site from corning up at a specific moment of the day. In fact, it has not been uncommon in SEA [Southeast Asia] to note a SAM site coming up one or two minutes after a preemptive launch."[97]

However difficult it was to determine the effectiveness of this tactic, it was used extensively, as reflected in the following tables for ARM employment between April and October of 1972.[98]

| US Anti-radiation Missile Employment, April -October 1972 | | | | |
|---|---|---|---|---|
| | USAF | | USN/USMC | |
| | AGM-45 | AGM-78 | AGM-45 | AGM-78 |
| | | | | |
| TOTAL MISSILES | 678 | 230 | 1257 | 165 |
| EVALUATED HIT | 1 | 2 | 19 | 4 |
| POSSIBLE HIT | 59 | 37 | 22 | 16 |
| EVALUATED MISS | 230 | 150 | 700 | 86 |
| POSSIBLE MISS | 5 | 0 | 4 | 2 |
| UNKNOWN | 59 | 39 | 250 | 56 |
| LOST ORDNANCE | 4 | 2 | 8 | 1 |
| PREEMPTIVE | 320 | 0 | 254 | 0 |
| SUPPRESSION | 118 | 67 | 453 | 58 |

EFFECTIVENESS

How effective were the Weasels in suppressing the North Vietnamese air defenses? That question is difficult to answer looking at the numbers above alone. The Weasels flew their last mission of the Vietnam War on August 3, 1973. "Between December of 1965 and August of 1973, Wild Weasel losses totaled forty eight aircraft--two F-100Fs and forty six F-105F/Gs."[99] These losses must be "...weighed against the hundreds of SAM sites destroyed and the thousands more forced off the air."[100] Even more telling is the reduction in aircraft loss rates. "During the

course of the air war over North Vietnam there had been a steady drop in the effectiveness of the SA-2 missile, as the various countermeasures took effect. When it was first used on a large scale, in 1965, the SA-2 destroyed about ten fighter- bombers for an estimated 150 Guidelines launched: an average of one kill for every fifteen missiles. By November 1968 one aircraft was being shot down for every 48 missiles fired. During Linebacker II one aircraft was destroyed for roughly every 50 Guidelines fired."[101]

The Weasels' effect is perhaps better seen in changes in North Vietnamese SAM employment. The Vietnamese soon recognized the vulnerability of fixed SAM sites to attacking tactical aircraft like the Wild Weasel. "Immediate steps were taken to establish a minimum of three alternate sites for each firing battalion and the abandonment of any of these alternate sites when believed compromised."[102] Use of the SA-2 system varied from an "area defense barrage fire concept to a highly mobile 'shoot and scoot' concept keyed to one time firings."[103] Important here is that while the missile crews were "scooting," they weren't shooting, reducing the numbers and density of the surface-to-air missile threat. Also, as early as 1967, the North Vietnamese established Fan Song radar shut down procedures to deny terminal target data to US missiles. Clearly the Wild Weasel had an effect on the North Vietnamese air defenses.

## CONCLUSIONS

The suppression of enemy air defenses had come a long way from the sporadic bombing and strafing of anti-aircraft artillery and machine guns in WW I. In WW II, radar clearly added to the effectiveness of those anti-aircraft defenses. Both the Allies and Germany recognized its effect. Luftwaffe ace Adolf Galland later acknowledged: "From the very beginning the British had an extraordinary advantage which we could never overcome throughout the entire war: radar and fighter control. For us and for our command this was a surprise, and a very bitter one."[104]

Suppression efforts continued much as they had in World War II through the Korean War and operations were largely limited to bombing and strafing AAA sites and searchlight bombing. However, the introduction of the SA-2 into Southeast Asia in the Vietnam War demanded a new solution to the SEAD problem.

That solution for the US Air Force was the Wild Weasel, although the Navy also developed anti-SAM aircraft and tactics. The two services emerged from the Vietnam War with two distinctive ideas for defense suppression, the USAF dependent on the highly-specialized Wild Weasel, and the Navy on preemptive launch and the use of nearly every naval tactical aircraft as a launch platform for an anti-radiation missile. Each has its place. The Navy's tactic is effective in a raid strategy where the defenses only need to be shut down for a short period of time. It is also effective for the Navy's primary mission, sea control, where ARMs would be launched to clear the defenses for attacks on enemy ships. However, in a prolonged SEAD campaign, or where specific threats need to be cleared to open the way for penetrating aircraft, the Weasel makes more sense. Its ability to target specific threats gives the Weasel a clear advantage over other methods of ARM employment --methods which degrade the range of the missile or its effectiveness.

Just as lethal suppression of enemy air defenses did not solve the flak problem in previous wars, the WEASEL alone did not solve the problem of surviving against the modern missile threat. Electronic countermeasures, improved warning equipment, and better tactics also played a role. But just as clearly, the radar-guided surface-to-air missile had not proved to be “the death of the flying air force,” and the Weasel had been instrumental in preserving airpower's role.

# EPILOGUE

Following the Vietnam War, the Wild Weasel underwent another transformation. Designed to counter the dense and sophisticated mobile Soviet missile threat, the Advanced Wild Weasel, the F-4G, included installation of the APR-38 Weasel electronics package in an F-4E airframe. The APR-38 was the heart of the F-4G system and allowed far more information to be processed about a given threat, including for the first time range --a problem identified by the first Weasel crews in Vietnam. Installation of the Weasel electronics dictated removal of the F-4E's internal M-61 gun from the nose, but the aircraft retained its other air- to-air and air-to-ground capabilities. The F-4G has been further modified in more recent years to include the APR-47 , an upgrade replacement for the APR-38.

Another improvement in the Wild Weasel's capability came with the introduction of the AGM-88 High-Speed Anti-Radiation Missile, or HARM. This very sophisticated weapon, developed by Texas Instruments for operational in the mid-1980s, is capable of being employed in three modes: (1) preemptive launch, in which the missile is launched without a radar signal present, (2) firing against a known threat in a range-unknown mode, and (3) launch in the range-known mode, the option that takes fullest advantage of the Weasel's avionics and the missile's capabilities.

## THE MEDITERRANEAN, 1986: THE US AND LIBYA SQUARE OFF

Following Vietnam, US defense suppression forces saw no action until March 1986. In that month, the US aircraft carriers USS America, Coral Sea, and Saratoga were placed in the Mediterranean Sea to conduct surface and flight operations in the Gulf of Sidra, south of the 32 degrees 30 minutes North latitude line claimed by Libya as the boundary of it national waters. The carrier task forces were participating in a previously announced US freedom of navigation exercise in international waters, outside the 12-mile limit prescribed by international law to

define national and international waters. The exercise followed months of increasing tensions in the Mediterranean beginning in January 1986 with numerous US intercepts of Libyan Arab Air Force aircraft, including MiG-25 Foxbats, MiG-23 Floggers, SU-22 Fitters, an IL-76 Candid used by the Libyans for maritime reconnaissance, and occasionally French-built Mirage Vs and F-ls.[105]

The US ships initially operated north of the $32^0$ 30' latitude line. However, on March 24th the US surface action group moved south of the Libyan-proclaimed "Line of Death" supported by combat air patrol (CAP) and surface attack combat air patrol (SUCAP) aircraft armed with a full complement of air- to-air and air-to-surface ordnance, including MK-20 Rockeye, High Speed Anti-Radiation Missiles, and HARPOON anti-ship missiles.[106] Early in the afternoon of the 24th, "the Libyan missile base at Sirte fired one or more Soviet-built SA-5 surface-to-air missiles at Navy aircraft flying in support of the surface ships in waters below the line claimed by Libya."[107] The missiles, fired against two F/A-1B Hornets operating from the USS Coral Sea in the southern-most CAP orbit, were fired at extreme range and were wide misses. [108] Later the same day, two Libyan MiG-25s flew into the airspace above the Gulf of Sidra, were intercepted by Navy aircraft, and returned uneventfully to their airfield.

Another SA-5 "firing event" occurred later that evening, and an SA-2 missile firing event, the same type missile employed by the North Vietnamese, was noted approximately 10 minutes after the SA-5 firing. The missile firings were called "firing events" because the Navy was not sure just how many missiles were fired, but it was at least one and probably more. Then, in a third missile firing on the 24th, "the Libyan missile site at Sirte fired another one or more SA-5s at US aircraft 20 minutes after the SA-2 launch. Up to this time, the Defense [Department] estimate[d] that there had been at least six surface-to-air missiles fired, probably two more, and

possibly 12 missiles launched against U. S. aircraft."[109]

US retaliation for the surface-to-air missile firings was initiated when a US Navy A-6 Intruder attacked a Libyan La Combattante high-speed missile patrol boat near Misratah with a HARPOON anti-ship missile and Rockeye, sinking it. Two Navy A-7Es from the USS Saratoga also fired HARM high-speed anti-radiation missiles against the SA-5 missile site at Sirte, and the radar site ceased to function, at least temporarily, after the attack. [110]

Later in the evening of March 24th, another Navy A-6 aircraft attacked a Libyan Nanuchka missile boat with Mk-20 Rockeye, a cluster munition with an armor-piercing capability, damaging it, but the boat was able to return to port.[111]

Shortly after midnight on the 25th, the USS Yorktown fired two Harpoon missiles against an unidentified surface vessel, sinking it. Later that morning, in the early hours of March 25th, two US Navy A-7s again fired HARM missiles at the radar site at Sirte, which was once again back in operation. The final action of the Gulf of Sidra confrontation occurred after sunrise that same day when two Navy A-6s, one from the Saratoga and one from the Coral Sea, fired weapons against another Nanuchka patrol boat that had left Libyan territorial waters near Benghazi, leaving it dead in the water. These events were merely a prelude for the action that would occur less than three weeks later, again bringing the US and Libya into conflict, and again bringing US defense suppression assets to bear.[112]

ROUND 2: APRIL 1986

The month following the first confrontation, then-President Reagan ordered the US Navy and Air Force to conduct strikes against Libya to "preempt far-reaching terrorist attacks that U.S. intelligence officials said have been planned since the first of the year by Libyan leader Col. Muammar Qaddafi and 'key lieutenants' on 30-35 American installations worldwide, including U.S. international air carriers in Latin America."[113] The raid was also conducted in retaliation for

the Libyan-sponsored bombing of a then-West Berlin night club in which one American service member was killed and 230 people injured, including about 50 US military personnel.[114] Planning began on April 7, and on April 15, approximately 100 US aircraft participated in the simultaneous raids against five targets around Tripoli and Benghazi. Aircraft involved in the strikes included 24 US Air Force F-111Fs from the 48th Tactical Fighter Wing at RAF Lakenheath in the United Kingdom, 6 of which acted as airborne spares and returned to base after the initial refueling; 5 EF-111As from the 42d Electronic Combat Squadron at RAF Upper Heyford, 3 of which would take part in the attack; 28 KC-10 and KC-135 tankers; Navy E-2Cs for surveillance; F-14s and F/A-18s; EA-6Bs for electronic countermeasures; and A-6Es for attack. The targets were "purported terrorist installations comprising command and control systems and training, logistics, intelligence and communications facilities."[115]

The attack scheme used the EF-111s and the EA-6Bs, equipped with similar jamming systems, for non-lethal or electronic defense suppression prior to the attack aircraft arriving over target. Six Navy F/A-18s and six A-7Es provided the lethal side of the defense suppression role. The A-7E is capable of firing both the AGM-45 Shrike and the AGM-88 HARM, while the F/A-18 is only HARM-capable, and together they fired nearly 50 anti-radiation missiles (12 Shrikes and about 36 HARM) at Libyan air defense sites.[116] Still, "the attacking aircraft encountered heavy surface-to-air missile activity near Tripoli and at one downtown target near Benghazi. The activity included SA-2, SA-3, SA-6, and SA-8 missiles."[117] Significantly, the SA-5 site at Sirte which was attacked during the Navy raids in March, came up as the attack aircraft were egressing the target area, but no missiles were fired from the site and no anti-radiation missiles were expended against it. Only one aircraft, a USAF F-111, was lost in the raid, for as yet unknown causes.

## THE PERSIAN GULF WAR, 1991

The next significant use of US defense suppression forces occurred with Operations Desert Shield/Desert Storm, beginning with the deployment of US forces to the Persian Gulf region in response to the Iraqi invasion of Kuwait and potential invasion of Saudi Arabia. After a nearly six month build-up, the war began in the pre-dawn morning of January 17, 1991, a war in which electronic warfare would playa greater role than in any previous conflict.[118] Phase I of the battle plan for coalition forces called for the weight of the coalition air effort to be thrown against the Iraqi air defense and command and control network, air force, and its Scud missiles. The goals of this phase were to gain and maintain air superiority, allowing freedom of action over Iraq for coalition air forces, and to destroy Iraq's ability to retaliate with its weapons of mass destruction. Phase II called for destruction of the defenses in the Kuwaiti theater of operations, followed by other phases aimed at cutting off the entrenched Iraqi forces in Kuwait and preparing the way for the ground assault.[119]

Coalition forces faced a modern, integrated air defense network armed with 600 surface-to-air missile units including Soviet SA-2, -3, -6, -7, -8, -9, -14, the Chinese HN-5, and French/German Roland 2 surface-to-air missiles and 10,000 anti- aircraft artillery units including the radar-controlled 57 mm, 85 mm, 100 mm, 130 mm, and the mobile ZSU-23-4 systems.[120]

Initial coalition air attacks took out early warning radars, microwave communications links, and primary air defense control sites, leaving the Iraqi air defenses crippled, without targeting information from the command and control system. “Some units could still find targets with their own radars, as long as they were not jammed, but the more they used their radars, the more they were exposed to direct attack by anti-radar missiles (ARMs). Within a few days, the surviving Iraqi SAMs would transmit for no more than 20 seconds at a time.”[121] Those sites that chose to transmit were attacked by F-4G Wild Weasels, F-16s, A-7s, and F/A-18s carrying HARMs.

While most of the details of the Desert storm electronic combat campaign remain classified, after the second or third day of the war, "... the Wild Weasels beat up on the enemy radar so bad that they essentially stopped radiating; and they'd come up for 4 or 5 seconds at a time and shoot and go back down again,"[122] leaving the missile unguided and ballistic. In fact, the Weasels were so effective that when the Iraqis passively detected the F-4G's distinctive APQ-120 radar, they would not bring up their SAM radars. When the coalition forces ran short of Weasels, they would "... just send a flight or two and have them fly around with their radar on for a little bit.

It got to the point where sometimes the Weasels would just turn their radar off so the enemy wouldn't know they were there, so they [the Weasels] could get some activity."[123] In all, the Weasels flew 2,331 combat sorties and 8,587 combat hours, proving their value in suppressing and intimidating (itself a form of suppression) the Iraqi air defenses in the Gulf War.[124]

## THE CURRENT NEED

Before the Gulf War, the Air Force had planned to end the Wild Weasel program, but its performance in the Gulf saved it from the budget chopping block for the time being. Current Air Force plans are to keep an F-4G Weasel capability in the Air National Guard until a "full-up" HARM capability can be integrated into the F-15E or F-16 weapons systems. That capability is some years down the road. In the interim, the F-16 will be equipped with a more generic and less-capable system that utilizes the HARM seeker head to find and identify threats, but the system does not provide a ranging capability, although the F-16 can employ the HARM in a range-known mode against a site whose geographic coordinates can be fixed. Other studies are underway. For example, McDonnell Douglas is investigating the installation of a more sensitive version of the F-15E's ALR-56 radar warning receiver, a modification that would provide emitter localization within approximately 1 degree instead of the 10 degrees now available.[125] Such cuing would allow the HARM to be fired in the range known mode, significantly increasing its

range capability over other means of employment. The ALR-56 has already been tested on the F-16C and could form a part of the F-16 study. General Dynamics has already equipped the F-16 with a HARM "shooter" capability, a capability put to good use in the Persian Gulf. Whether that successor aircraft is a dedicated Weasel or possesses merely an add-on capability remains to be seen. In any event, the SEAD mission demands a capable aircraft, an aircraft able to employ suppression munitions at their full capability, not in some degraded mode.

However, just as the Weasel alone did not solve the problem of surviving in a dense electronic warfare environment in Vietnam, we cannot depend solely on the Wild Weasel for electronic combat support in the future. The Weasel must be complemented by a full range of electronic countermeasures, including self-protection jammers, chaff, flares, decoys, and stand-off and penetration jamming platforms such as the EF-111 and EA-6B. The future requirement for a Wild Weasel is clearly indicated; however, only when used as part of a fully integrated electronic combat program will it be fully effective. That is the end toward which we must proceed.

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